**<u>WHAT IS CLAIMED IS</u>:**

1. A method for obtaining spatial information about an object, the method comprising:

interacting electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes; and

using the plurality of measured resonant transverse magnetic modes to obtain the spatial information for the object.

2. A method as recited in claim 1, wherein the use of the plurality of measured resonant transverse magnetic modes to obtain the spatial information for the object comprises:

using the plurality of measured resonant transverse magnetic modes to obtain spatial information about positions of the measured transverse magnetic modes; and

using the spatial information about the positions of the measured transverse magnetic modes to obtain the spatial information about the object.

3. A method as recited in claim 2, wherein the use of the plurality of measured resonant transverse magnetic modes to obtain spatial information about positions of the measured transverse magnetic modes comprises using a Fourier Bessel transform.

4. A method as recited in claim 2, wherein the use of the plurality of measured resonant transverse magnetic modes to obtain spatial information about positions of the measured transverse magnetic modes comprises using parameters relating to the object.

5. A method for obtaining spatial information about an object, the method comprising:

providing a cavity for containing the object;

positioning the object in the cavity;

interacting electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes in the cavity; and

using the plurality of measured resonant transverse magnetic modes to obtain the spatial information for the object.

6. A method as recited in claim 5, wherein the interacting of the electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes in the cavity comprises, for each of the frequencies, measuring a frequency shift relative to a base frequency.

7. A method for measuring the dielectric constant of an object, the method comprising:

interacting electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes; and

using the plurality of measured resonant transverse magnetic modes to obtain the dielectric constant for the object.

8. A method as recited in claim 7, wherein:

the electromagnetic radiation at a given one of the plurality of frequencies comprises a set of base frequencies;

each of the plurality of measured resonant transverse magnetic modes corresponding to the given one of the plurality of frequencies comprises a frequency shift relative to the base frequencies.

9. A method for measuring the dielectric constant of an object, the method comprising:

interacting electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes, the measured resonant transverse magnetic modes comprising dielectric constant information and spatial information relating to the object;

using the plurality of measured resonant transverse magnetic modes to obtain the spatial information;

using the using the plurality of measured resonant transverse magnetic modes and the spatial information to obtain the dielectric constant information and the dielectric constant for the object.

10. A method as recited in claim 9, wherein the obtaining of the plurality of measured resonant transverse magnetic modes comprises obtaining $TM_{0np}$ modes, wherein n and p assume ascending integer values.

11. A method as recited in claim 10, wherein the plurality of measured resonant transverse magnetic modes comprise at least the first four of the ascending $TM_{0np}$ modes.

12. A method as recited in claim 10, wherein the obtaining of the plurality of measured resonant transverse magnetic modes comprises measuring a frequency shift corresponding to a difference between a base frequency and each of the measured resonant transverse magnetic modes.

13. A method as recited in claim 9, wherein the using of the plurality of measured resonant transverse magnetic modes to obtain the spatial information comprises obtaining a position for each of the measured resonant transverse magnetic modes, and correlating the position of the measured resonant transverse magnetic mode with the spatial position of the object.

14. A method as recited in claim 13, wherein the correlating comprises superposing the position for the measured resonant transverse magnetic mode in a Fourier-Bessel construction to obtain the spatial position of the object.

15. A method for measuring the dielectric constant of an object, the method comprising:

positioning the object in a cavity;

interacting electromagnetic radiation at a plurality of frequencies with the object to obtain a corresponding plurality of measured resonant transverse magnetic modes, each of the measured resonant transverse magnetic modes comprising dielectric constant information and spatial information relating to the object;

using the plurality of measured resonant transverse magnetic modes to obtain the spatial information;

using the using the plurality of measured resonant transverse magnetic modes and the spatial information to obtain the dielectric constant information and the dielectric constant for the object.

16. An apparatus for obtaining spatial information relating to an object, the apparatus comprising:

a cavity having a size and a shape sufficient to physically accommodate the object;

an antenna system for directing electromagnetic radiation comprising a plurality of frequencies into the cavity, and for receiving a corresponding plurality of measured resonant transverse magnetic modes; and

a signal processor operatively coupled to the antenna system for processing the measured resonant transverse magnetic modes to obtain the spatial information relating to the object.

17. An apparatus for measuring the dielectric constant of an object, the apparatus comprising:

a cavity having a size and a shape sufficient to physically accommodate the object;

an antenna system for directing electromagnetic radiation comprising a plurality of frequencies into the cavity, and for receiving a corresponding plurality of measured resonant transverse magnetic modes; and

a signal processor operatively coupled to the antenna system for processing the measured resonant transverse magnetic modes to obtain the dielectric constant for the object.

18. An apparatus as recited in claim 17, wherein the cavity is substantially cylindrical in shape.

19. An apparatus as recited in claim 18, wherein:

each of the plurality of resonant transverse magnetic modes has a resonant frequency;

the cavity has a height h and a radius R ; and

the ratio of the height h to the radius R is selected to cause the resonant frequencies to be distinct from one another.

20. An apparatus as recited in claim 18, wherein:

the cavity has a height h and a radius R ; and

the ratio of the height h to the radius R is about 0.3 to about 2.7.

21. An apparatus as recited in claim 18, wherein:

the cavity has a height h and a radius R ; and

a ratio of the height h to the radius R is about 1.25.

22. An apparatus as recited in claim 18, wherein:

the cavity has a height h and a radius R; and

a ratio of the height h to the radius R is about 0.34.

23. An apparatus as recited in claim 17, wherein the cavity comprises a substantially non-conductive support within the cavity for supporting the object.

24. An apparatus as recited in claim 23, wherein the shelf comprises a glass material.

25. An apparatus as recited in claim 17, wherein:

the cavity comprises a substantially cylindrical shape and comprises a cavity axis that is coincident with a cylinder axis; and

the antenna system is configured to receive the corresponding plurality of measured resonant transverse magnetic modes at the cavity axis.

26. An apparatus as recited in claim 17, wherein the antenna system comprises an antenna for directing the electromagnetic radiation and for receiving the corresponding plurality of measured resonant transverse magnetic modes.

27. An apparatus as recited in claim 26, wherein the antenna is a single radiating element.

28. An apparatus as recited in claim 27, wherein the single radiating element comprises a whip antenna.

29. An apparatus as recited in claim 26, wherein:

the cavity comprises a substantially cylindrical shape and comprises a cavity axis that is coincident with a cylinder axis; and

the antenna is configured to receive the corresponding plurality of measured resonant transverse magnetic modes at the cavity axis.

30. An apparatus as recited in claim 17, wherein the antenna system comprises:

a radiating element for directing the electromagnetic radiation; and

a receiving element for receiving the corresponding plurality of measured resonant transverse magnetic modes.

31. An apparatus as recited in claim 30, wherein the receiving element comprises a whip antenna.

32. An apparatus as recited in claim 30, wherein:

the cavity comprises a substantially cylindrical shape and comprises a cavity axis that is coincident with a cylinder axis; and

the receiving element is configured to receive the plurality of measured resonant transverse magnetic modes at the cavity axis.

33. An apparatus as recited in claim 30, wherein:

the radiating element has a radiating element axis;

the receiving element has a receiving element axis; and

the radiating element axis is located substantially orthogonally with respect to the receiving element axis.

34. An apparatus as recited in claim 17, wherein:

the shape of the cavity is substantially cylindrical and the cavity comprises a side wall, an end face, and a cylindrical axis extending through the end face;

the radiating element is disposed in the side wall of the cavity; and

the receiving element is disposed in the end face substantially at the cylindrical axis.

35. An apparatus as recited in claim 17, wherein:

the antenna system is positioned with respect to the cavity to receive azimuthally symmetric ones of the plurality of measured resonant transverse magnetic modes; and

the signal processor comprises circuitry for processing the azimuthally symmetric ones of the plurality of measured resonant transverse magnetic modes.

36. An apparatus as recited in claim 17, wherein:

each of the measured resonant transverse magnetic modes comprises a resonant frequency;

the plurality of measured resonant transverse magnetic modes comprise sequential ones of the measured resonant transverse magnetic modes, the sequential ones of the measured resonant transverse magnetic modes increasing as a function of an increase in the resonant frequency of the sequential ones of the measured resonant transverse magnetic modes; and

the signal processor comprises circuitry for processing a first set of the sequential ones of the measured resonant transverse magnetic modes for measuring the dielectric constant value, the first set of measured resonant transverse magnetic modes comprising a lowest range of the sequential ones of the measured resonant transverse magnetic modes.

37. An apparatus as recited in claim 36, wherein:

the lowest range comprises the four lowest sequential ones of the measured resonant transverse magnetic modes.